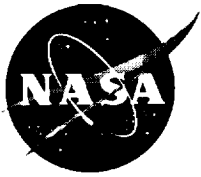


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**Technical Report Series on the
Boreal Ecosystem-Atmosphere Study (BOREAS)**

Forrest G. Hall and Jaime Nickeson, Editors

Volume 73

**BOREAS RSS-17 1994 ERS-1 Level-3
Freeze/Thaw Backscatter Change Images**

E. Rignot, J.B. Way, and K.C. McDonald

National Aeronautics and
Space Administration

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**BOREAS RSS-17 1994 ERS-1 Level-3
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BOREAS RSS-17 1994 ERS-1 Level-3 Freeze/Thaw Backscatter Change Images

Eric Rignot, JoBea Way , Kyle C. McDonald

Summary

The BOREAS RSS-17 team acquired and analyzed imaging radar data from the ESA's ERS-1 over a complete annual cycle at the BOREAS sites in Canada in 1994 to detect shifts in radar backscatter related to varying environmental conditions. Two independent transitions corresponding to soil thaw and possible canopy thaw were revealed by the data. The results demonstrated that radar provides an ability to observe thaw transitions at the beginning of the growing season, which in turn helps constrain the length of the growing season. The data set presented here includes change maps derived from radar backscatter images that were mosaicked together to cover the southern BOREAS sites. The image values used for calculating the changes are given relative to the reference mosaic image. The data are stored in binary image format files.

Due to copyright issues, the 01-March-1994 reference image is not included on the CD-ROM and is not publicly available. See Sections 15 and 16 for information about how to possibly acquire the data.

Note that some of the data files on the BOREAS CD-ROMs have been compressed using the Gzip program. See Section 8.2 for details.

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1. Data Set Overview

1.1 Data Set Identification

BOREAS RSS-17 1994 ERS-1 Level-3 Freeze/Thaw Backscatter Change Images

1.2 Data Set Introduction

Synthetic Aperture Radar (SAR) data acquired by the European Space Agency's (ESA's) Earth Remote Sensing Satellite (ERS-1) over a complete annual cycle at the BOREal Ecosystem-Atmosphere Study (BOREAS) test sites in Canada in 1994 were analyzed to detect shifts in radar backscatter related to varying environmental conditions. The data set presented here includes change maps in radar backscatter mosaicked together over the southern BOREAS sites and the reference mosaic image, acquired in winter when the landscape was in a frozen state, used for calculating those changes.

1.3 Objective/Purpose

The aim of the study was to demonstrate that imaging radar could be utilized to detect the onset of the thaw process during a spring transition. It had already been demonstrated that imaging radar can be utilized to pick up the freeze transition in the fall season (Rignot and Way, 1994). Knowing the dates of onset of freeze/thaw events is required to determine the length of the growing season, with obvious implications for carbon exchange. The ERS-1 remote sensing data were compared to in situ air temperature, soil temperature, and xylem flow data (see Section 1.6) collected at the Southern Study Area (SSA) Old Black Spruce (OBS) site.

1.4 Summary of Parameters

- Radar backscatter of reference scene expressed in Digital Number (DN) values between 0 and 255. To convert the DN values into radar cross-section numbers in decibels (dB), use the following formula:

$$\text{radar cross-section (dB)} = 10 \cdot \log_{10} (\text{DN} \cdot \text{DN} \cdot 1.2 \cdot 10^{-5})$$

- Radar backscatter change maps for other scenes in dB relative to the scene of reference (Winter scene) expressed in DN values between 0 and 255. DN = 0 corresponds to -3dB change or lower. DN=255 corresponds to +3 dB change.

1.5 Discussion

None given.

1.6 Related Data Sets

BOREAS RSS-17 Dielectric Constant Profile Measurements

BOREAS RSS-17 Stem and Air Temperature Measurements

BOREAS RSS-17 Xylem Flux Density Measurements at the SSA-OBS Site

2. Investigator(s)

2.1 Investigator(s) Name and Title

JoBea Way, JPL

Reiner Zimmerman, JPL

Kyle McDonald, JPL

Eric Rignot, JPL

2.2 Title of Investigation

Freeze/Thaw Transitions as Observed with ERS-1 Imaging Radar at BOREAS

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3. Theory of Measurements

At microwave frequencies, freezing results in a dramatic decrease of the dielectric constant of soil and vegetation, which significantly alters their radar scattering properties. Using ERS-1 SAR data collected along a north-south Alaskan transect, Rignot and Way (1994) showed that it was possible to detect the onset of freezing by mapping areas whose radar backscattering intensity dropped by 3 dB or more relative to a reference scene acquired during the summer season. The ERS results were compared to air-temperature data collected at weather stations and in situ observations of forest stands. The technique utilizes repeat-pass SAR data that are mosaicked together and coregistered to the reference image on a pixel-by-pixel basis. The spatial resolution of the pixel elements is of several tens of meters. The technique operates independent of cloud cover and surface topography (change detection techniques do not require topographic information to measure backscatter changes). In Alaska, the technique was also shown to be relatively independent of land cover types, with the exception of open water areas, which behave in a completely different manner. Results obtained later over the Bonanza Creek Experimental Forest, AK, and at BOREAS, however, indicate that over forested terrain, the change in radar backscatter corresponding to freeze/thaw transitions may be slightly lower in magnitude than that recorded on nonforested areas.

4. Equipment

4.1 Sensor/Instrument Description

ERS-1 was launched on 17-Jul-1991 by an Ariane 4 launcher from Kourou, French Guiana. Its total mass is 2157.4 kg, 888.2 kg from the payload and 1257.2 kg from the platform. The peak power supplied to the payload is 2600 W; payload average power is at most 550 W. The voltage of the power supply varies between 23 V and 37 V, with a maximum onboard energy of 2650 WH. ERS-1 is a three-axis stabilized spacecraft with a design lifetime of 2 to 3 years.

ESA sponsored the mission. The prime contractor is Dornier (Federal Republic Germany). Co-contractors include Fokker (The Netherlands), Laben (Italy), Matra (France), MDA (Canada), Marconi (United Kingdom), and Selenia (Italy).

AMI Image-Mode (SAR) Characteristics:

Antenna Size:	10 m x 1 m
Peak Power:	4.8 kW
Frequency:	5.3 GHz (C-Band)
Bandwidth:	15.55 +/- 0.1 MHz
PRF Range:	1640-1720 Hz in 2-Hz steps
Polarization:	Linear-Vertical (LV)
Long Pulse:	37.12 +/- 0.06 microseconds
Compressed Pulse Length:	64 nanoseconds
Sampling Window:	296 microseconds (99-km telemetered swath)
Analog/Digital	
Complex Sampling:	16.96 million samples/second
Quantization:	5I, 5Q if range compression on ground (nominal 6I, 6Q if range compression onboard)
Data Rate:	< 105 Mbit/s
Spatial Resolution:	30 m x 30 m
Radiometric Resolution:	2.5 dB at sigma-naught = -18 dB
Noise-Equivalent	
Sigma-Naught:	-23 dB
Incidence Angle:	23° at mid-swath
Swath Stand-Off:	250 km to side of orbital track
Swath Width:	100 km

4.1.1 Collection Environment

The ERS-1 satellite orbits Earth in a sun-synchronous, polar, near-circular orbit at a mean altitude of 785 km and an inclination of 98.5 degrees.

4.1.2 Source/Platform

ERS-1 has a sun-synchronous, polar, near-circular orbit at a mean altitude of 785 km and an inclination of 98.5 degrees. During the initial 3 months of the commissioning phase, the satellite had a 3-day repeat cycle at an altitude of 785 km (this is known as the reference orbit). Subsequent satellite height adjustments have provided two multidisciplinary phases with a 35-day repeat cycle, two ice phases with 3-day repeat cycles, and two geodetic phases with 168-day with cycles. The majority of the mission has been performed in the 35-day repeat cycles. ERS-1, operating in tandem with ERS-2, is expected to remain in a 35-day repeat cycle for the rest of its mission. Since ERS-1 has no onboard recorders except for an onboard tape recorder for bit rate data, Active Microwave Instrumentation (AMI) data can be obtained only if there is a ground station in view of the orbiting satellite.

4.1.3 Source/Platform Mission Objectives

ERS-1 is an ESA satellite devoted to remote sensing from a polar orbit. It provides global and repetitive observations of the environment using techniques that allow imaging to take place irrespective of weather conditions. ERS-1 has a sun-synchronous, polar, near-circular orbit with a

mean altitude of 785 km.

List of Sensors/Instruments:

- **AMI:** AMI combines the functions of a SAR and a Wind Scatterometer (WNS). The AMI measures wind fields and wave spectra over the open ocean and records all-weather, fine-resolution images over the ocean, polar ice, coastal zones, and land. The AMI has an image mode (swath) SAR. SAR mode and Wind/Wave mode are mutually exclusive during operation.
- **Radar Altimeter (RA):** RA provides measurements of altitude, significant wave heights, and surface wind speed over the ocean, and various parameters over sea ice and ice sheets.
- **Along-Track Scanning Radiometer (ATSR):** ATSR is an experimental four-channel infrared radiometer that provides precise and accurate measurements of sea surface temperatures and cloud top temperatures.
- **Microwave Sounder (MWS):** MWS is a two-channel passive microwave radiometer that provides information on the total precipitable water vapor and the total liquid water content of the atmosphere.
- **Precise Range and Range-rate Equipment (PRARE):** PRARE is an experimental instrument providing high-precision orbit data in support of the altimeter mission. This instrument does not work.
- **Laser Retroreflector (LR):** LR permits the use of ground based laser ranging to determine precise orbit and calibration information in support of the altimeter mission.

4.1.4 Key Variables

Radar backscatter.

4.1.5 Principles of Operation

In image mode, the SAR obtains strips of high-resolution imagery 100 km in width to the right of the satellite track. The 10-m-long antenna, aligned parallel to the flight track, directs a narrow radar beam onto Earth's surface over the swath. Imagery is built up from the time delay and strength of the return signals, which depend primarily on the roughness and dielectric properties of the surface and its range from the satellite.

The SAR's fine resolution in the range direction is achieved by phase coding the transmit pulse with a linear chirp and compressing the echo by matched filtering. Range resolution is obtained from the travel time. Azimuth resolution is achieved by recording the phase as well as the amplitude of the echoes along the flight path. The set of echoes over a flight path of about 800 m is processed (on the ground) as a single entity, giving an azimuth resolution equivalent to a real aperture 800 m in length. This is the 'synthetic aperture' of the radar.

Operation in image mode excludes the other AMI operating modes, and power considerations limit operating time to a maximum of 10 minutes per orbit. Because the data rate of 100 Mbit/s is far too high to allow onboard storage, images are acquired only within the reception zone of a suitably equipped ground station.

4.1.6 Sensor/Instrument Measurement Geometry

ERS-1 operates a C-band (5.7-cm wavelength), vertical receive and transmit polarization SAR, illuminating the surface at a 23-degree incidence angle from nadir. The swath width is 100 km x 100 km, with 30-m resolution for four looks. The data were processed at a 200-m resolution for this regional study.

4.1.7 Manufacturer of Sensor/Instrument

ESA sponsored the ERS-1 mission. The prime contractor is Dornier (Federal Republic Germany). Co-contractors include Fokker (The Netherlands), Laben (Italy), Matra (France), MDA (Canada), Marconi (United Kingdom), and Selenia (Italy).

Some of the major participants include:

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0 75 45 8-0 (tel)

Marconi Thomsom
(United Kingdom Branch)
Anchorage Road
Portsmouth Hampshire
PO3 5PU England
44 705 66 49 66 (tel)

4.2 Calibration

The ERS data were collected, processed, and fully calibrated at NASA's Alaska SAR Facility (ASF) to yield slant-range radar backscatter images. Earlier engineering tests and experiments demonstrated that the data were calibrated with an absolute precision of about 2 dB and a relative accuracy of 1/3 dB (which is the stability of the ERS-1 system).

4.2.1 Specifications

Calibration of the AMI is undertaken in two steps. An internal calibration unit continuously monitors the out put power and receiver gain of the AMI over short intervals, and in SAR modes, the phase characteristics of the transmit signal. Antenna patterns and gains were measured on the ground and then, from time to time, in orbit. In the SAR modes, corner reflectors are used.

4.2.1.1 Tolerance

The parameter derived from the SAR image mode is the normalized radar backscattering coefficient, sigma-naught. ESA engineer Henry Laur has shown that the ERS-1 image mode SAR relative accuracy is 0.18 dB (1 sigma). ASF ERS-1 SAR image data are sufficiently monitored and calibrated to ensure +/- 1.0 dB relative accuracy and +/- 2.0 dB absolute accuracy.

4.2.2 Frequency of Calibration

Each ERS satellite's image mode SAR is checked against external calibration targets as often as the orbit and acquisition schedules allow. The orbit phases have repeat times of 3 days, 35 days, and 168 days. The latter two phases provide coverage over the ASF calibration sites more than once per repeat time period. Scheduling conflicts, equipment failures, and other factors reduce the number of available calibration passes. SAR image mode data are checked for miscalibration every 2 weeks.

4.2.3 Other Calibration Information

Image calibration coefficients vary with image type, processor gain setting, etc., and are provided in the metadata accompanying each image produced by the ASF. The radiometric calibration has never needed to be adjusted.

5. Data Acquisition Methods

The data were obtained as standard products from the ASF SAR facility.

6. Observations

6.1 Data Notes

See Way et al., 1997.

6.2 Field Notes

None given.

7. Data Description

7.1 Spatial Characteristics

7.1.1 Spatial Coverage

The coverage of the imagery is 100 km across by up to 1,000 km in the along-track direction. Two sets of image sizes are included in this data set. The images acquired before the reference date (01-March-1994) are all 1,024 samples by 3,086 lines in size. These images are shorter in the number of lines because ERS did not acquire the entire swath crossing the Prince Albert area. The shorter images coincide with the lower half of the reference and postreference images. The reference image and the images acquired after that date are all 1,024 samples by 8,552 lines in size. The last line of all the image files is coincident in geographic location. The only coordinates given for these change images is the center latitude and longitude of each set. The center latitude, longitude of the shorter (prereference) images is 60.2°N, 108.6°W. The center latitude, longitude of the longer (postreference) images is 53.3°N, 105.4°W. The data are in the slant-range radar geometry.

The North American Datum of 1983 (NAD83)
corner coordinates of the BOREAS region are:

	Latitude	Longitude
	-----	-----
Northwest	59.979°N	111.000°W
Northeast	58.844°N	93.502°W
Southwest	51.000°N	111.000°W
Southeast	50.089°N	96.970°W

The NAD83 corner coordinates of the SSA are:

	Latitude	Longitude
	-----	-----
Northwest	54.319°N	106.227°W
Northeast	54.223°N	104.236°W
Southwest	53.513°N	106.320°W
Southeast	53.419°N	104.368°W

7.1.2 Spatial Coverage Map

A coverage map is shown in Figure 1 of Way et al., 1997.

7.1.3 Spatial Resolution

The spatial resolution of this product is 200 m.

7.1.4 Projection

The data are in the slant-range radar geometry.

7.1.5 Grid Description

Not applicable.

7.2 Temporal Characteristics

7.2.1 Temporal Coverage

The dates of data acquisition by orbit are:

Orbit	Date
-----	-----
12904	03-Jan-1994
13205	24-Jan-1994
13377	05-Feb-1994
13506	14-Feb-1994
13635	23-Feb-1994
13678	26-Feb-1994
13721	01-Mar-1994 (reference)
13764	04-Mar-1994
13807	07-Mar-1994
13850	10-Mar-1994
13893	13-Mar-1994
13936	16-Mar-1994
13979	19-Mar-1994

7.2.2 Temporal Coverage Map

Not available.

7.2.3 Temporal Resolution

The potential temporal resolution of the data is 3 days, but not all orbits were acquired by ASF.

7.3 Data Characteristics

7.3.1 Parameter/Variable

The parameters contained in the data are:

- Radar backscatter of reference scene
- Radar backscatter change maps

7.3.2 Variable Description/Definition

The description of the parameters contained in the data are:

- The radar backscatter of the 01-March-1994 reference scene is expressed in DN (digital number) values between 0 and 255. To convert the DN values into radar cross-section numbers in decibels, use the formula,

$$\text{radar cross-section (dB)} = 10 \log_{10} (\text{DN} * \text{DN} * 1.2 * 10^{-5})$$

- Radar backscatter change maps for other scenes in decibels (dB) relative to the scene of reference (winter scene) expressed in DN values between 0 and 255.

DN = 0 corresponds to more than 3 dB decrease

DN = 255 corresponds to more than 3 dB increase

7.3.3 Unit of Measurement

The images are provided are digital numbers. Use the equations given above to calculate radar backscatter in decibels.

7.3.4 Data Source

European Remote Sensing Satellite, ERS-1.

7.3.5 Data Range

The range of values in each image is 0 to 255.

7.4 Sample Data Record

Not applicable to image data.

8. Data Organization

8.1 Data Granularity

The smallest unit of data available is the entire set of change images.

8.2 Data Format(s)

8.2.1 Uncompressed Format

The entire data set consists of 13 images divided into two sets. The six images acquired before the reference date (01-Mar-1994) contain 1,024 pixels in each of 3,086 lines. These images are shorter in the number of lines because ERS did not acquire the entire swath crossing the Prince Albert area. The shorter images coincide with the lower half of the reference and postreference images. The reference image and the six acquisitions after that date each contain 1,024 pixels in each of the 8,552 lines. The last line of all the image files is coincident in geographic location. Descriptions of the files are:

File	Description	Pixels	Lines
1	jan-03_mref	1024	3086
2	jan-24_mref	1024	3086
3	feb-05_mref	1024	3086
4	feb-14_mref	1024	3086
5	feb-23_mref	1024	3086
6	feb-26_mref	1024	3086
7	mar-01_refimg*	1024	8552
8	mar-04_mref	1024	8552
9	mar-07_mref	1024	8552
10	mar-10_mref	1024	8552
11	mar-13_mref	1024	8552
12	mar-16_mref	1024	8552
13	mar-19_mref	1024	8552

The description, (date)mref, signifies radar backscatter change between the date given and the reference image (01-Mar-1994). For the orbits associated with the image dates, see Section 7.2.1.

Note that the reference backscatter image of 01-Mar-1994 is not distributable. To obtain information regarding the acquisition of raw backscatter imagery, see Sections 15 and 16.

8.2.2 Compressed CD-ROM Files

On the BOREAS CD-ROMs, image files 1 to 6 and 8 to 13 have been compressed with the Gzip (GNU zip) compression program (file_name.gz). These data have been compressed using gzip version 1.2.4 and the high compression (-9) option (Copyright (C) 1992-1993 Jean-loup Gailly). Gzip uses the Lempel-Ziv algorithm (Welch, 1994) also used in the zip and PKZIP programs. The compressed files may be uncompressed using gzip (with the -d option) or gunzip. Gzip is available from many Web sites (for example, the ftp site prep.ai.mit.edu/pub/gnu/gzip-*.*) for a variety of operating systems in both executable and source code form. Versions of the decompression software for various systems are included on the CD-ROMs.

9. Data Manipulations

9.1 Formulae

Radar backscatter changes between -3 dB and +3 dB are linearly stretched between 0 and 255 (see above).

9.1.1 Derivation Techniques and Algorithms

The technique used is the same as that described by Rignot and Way (1994).

9.2 Data Processing Sequence

9.2.1 Processing Steps

The data were mosaicked together and automatically registered using image offsets determined by Fourier analysis of the radar scenes. The change in radar backscatter was then computed in the logarithm domain and stretched between 0 and 255.

BOREAS Information System (BORIS) staff compressed the binary image files for release on CD-ROM.

9.2.2 Processing Changes

None.

9.3 Calculations

9.3.1 Special Corrections/Adjustments

None.

9.3.2 Calculated Variables

The same scale/calibration factor was applied to all images to ensure that the changes in radar backscatter were relatively consistent. The scale factor utilized was that of the reference image. Other images were scaled accordingly.

9.4 Graphs and Plots

The plots referred to here are at the end of this document.

Plot 1 shows the variation in absolute radar backscatter of the black spruce study site in the SSA versus DOY.

The onset of thawing was detected in between 01-Mar-1994 and 05-Mar-1994, with a relative change in backscatter of about 1.5 dB. The thawed areas progressively extended in size and northward with time.

The early mosaics are shorter in length because ERS data were not acquired along the entire transect at that time. The scenes acquired between 04-Jan-1994 and 19-Mar-1994 corresponded to the 1994 Ice Phase of the ERS-1 SAR satellite, which provided exact repeat-pass data over the same sites every 3 days. Later acquisition of ERS-1 SAR data over the BOREAS study sites corresponded to a 35-day repeat cycle that could not be used directly to produce change detection maps. The BOREAS sites could still be imaged about every 2 weeks, but at a different location within the SAR swath, therefore limiting the possibilities to automatically coregister the data on a pixel-by-pixel basis. Analysis of changes in radar backscatter for those later scenes was therefore conducted over small test areas instead of the entire scenes.

Note that lakes, rivers, and other areas of open water behave differently than the rest of the landscape, so the change in detection technique is not applicable other than these areas, as discussed in Rignot and Way (1994).

10. Errors

10.1 Sources of Error

Given the stability of the ERS instrument, instrument errors are unlikely to cause erroneous changes in radar backscatter from the surface. Environmental factors may, however, complicate the interpretation of the data. To derive the freeze/thaw change products from ERS, the influence of snow is neglected because Alaskan snow is typically cold and dry and therefore transparent to radar signals. During warm episodes in the fall and/or the onset of spring, however, snow will become wet and its radar backscatter will rapidly drop to low values. In those circumstances, melting snow and freeze/thaw transitions may be more difficult to identify in the absence of ancillary information, for instance air/snow temperature. In the fall, there may be alternating freeze/thaw periods before the land freezes in for the whole winter. During those periods, if snow is already present on the ground, it may have a disturbing effect on the radar signature from the surface, which may be difficult to interpret in terms of freeze/thaw of the soils and vegetation beneath the snow cover.

10.2 Quality Assessment

10.2.1 Data Validation by Source

ERS-1 data are calibrated within 1/3 dB (Rignot et al., 1994; Rignot and Way, 1994). One data point (25-Jun-1994) was difficult to interpret because it exhibited a higher than expected radar signature, but nothing was found wrong with the processing of the data.

10.2.2 Confidence Level/Accuracy Judgment

The data quality is good over low-land vegetation and forest. The change detection approach does not work on open water, so the signatures of lakes and rivers will appear as erroneous in the map.

10.2.3 Measurement Error for Parameters

Ground truth data are not available to validate the mapping and estimate the measurement error except at one study site. At that one site, the procedure was found to detect the freeze/thaw transition correctly.

10.2.4 Additional Quality Assessments

[Include figure 7 here]

10.2.5 Data Verification by Data Center

BORIS staff has viewed the imagery to verify image sizes and format and to verify the coincidence of the last line in the two sets of image sizes.

11. Notes

11.1 Limitations of the Data

None given.

11.2 Known Problems with the Data

ERS-1 data are calibrated within 1/3 dB (Rignot et al., 1994; Rignot and Way, 1994). One data point (25-Jun-1994) was difficult to interpret because it exhibited a higher than expected radar signature, but nothing was found wrong with the processing of the data.

11.3 Usage Guidance

Before uncompressing the Gzip files on CD-ROM, be sure that you have enough disk space to hold the uncompressed data files. Then use the appropriate decompression program provided on the CD-ROM for your specific system.

11.4 Other Relevant Information

ESA has a policy that ERS-1 data should be distributed only to ESA-approved investigators; hence, the reference ERS-1 mosaic should not be utilized per se without first requesting an authorization from ESA. ERS change maps, which correspond to a higher level product, can be utilized with no restriction.

To obtain ERS data, interested users need to contact ESA and in particular the ESA/ESRIN Facility at Frascati. U.S. investigators interested in data available at the ASF should contact Greta Reynolds at the Alaska SAR Facility, University of Alaska, Fairbanks in Fairbanks, AK. The investigator will have to submit a short research project summary explaining the need for the data and how they will be utilized, and ASF will provide ERS data free of charge.

12. Application of the Data Set

These data can be used to determine the onset of thawing at different latitudes along the BOREAS study sites.

13. Future Modifications and Plans

This type of analysis may be pursued using SAR data collected by the Radarsat Canadian SAR at C-band horizontal polarization, or by the Ku-band NSCATT scatterometer launched in 1996.

14. Software

14.1 Software Description

Software has been developed at the Jet Propulsion Laboratory (JPL) to generate ERS-1 mosaics. Gzip (GNU zip) uses the Lempel-Ziv algorithm (Welch, 1994) used in the zip and PKZIP commands.

14.2 Software Access

Programs to generate ERS-1 mosaics were written in IDL and are available upon request. Gzip is available from many Web sites across the Internet (for example, FTP site prep.ai.mit.edu/pub/gnu/gzip-*.) for a variety of operating systems in both executable and source code form. Versions of the decompression software for various systems are included on the CD-ROMs.

15. Data Access

The imaging radar data are available from the Earth Observing System Data and Information System (EOSDIS) Oak Ridge National Laboratory (ORNL) Distributed Active Archive Center (DAAC).

15.1 Contact Information

For BOREAS data and documentation please contact:

ORNL DAAC User Services
Oak Ridge National Laboratory
P.O. Box 2008 MS-6407
Oak Ridge, TN 37831-6407
Phone: (423) 241-3952
Fax: (423) 574-4665
E-mail: ornldaac@ornl.gov or ornl@eos.nasa.gov

15.2 Data Center Identification

Earth Observing System Data and Information System (EOSDIS) Oak Ridge National Laboratory (ORNL) Distributed Active Archive Center (DAAC) for Biogeochemical Dynamics
<http://www-eosdis.ornl.gov/>.

15.3 Procedures for Obtaining Data

Although the reference image of the BOREAS RSS-17 freeze/thaw image data set is stored in a public archive, copyright restrictions limit the distribution and use of the data. The BOREAS CD-ROM series is publicly available and the change images on the CD-ROMs are available for unrestricted use.

ESA has a policy that ERS-1 data may be distributed only to ESA-approved investigators; hence, the reference ERS-1 image may not be utilized without first requesting an authorization from ESA. The ERS change maps, which correspond to a higher level product, can be utilized with no restriction.

To obtain ERS data, interested users need to contact ESA and in particular the ESA/ESRIN Facility at Frascati. U.S. investigators interested in data available at the ASF should contact Greta Reynolds at the Alaska SAR Facility, University of Alaska, Fairbanks in Fairbanks, AK. The investigator will have to submit a short research project summary explaining the need for the data and how they will be utilized. If appropriate, ASF will subsequently provide ERS data free of charge.

Users may obtain data directly through the ORNL DAAC online search and order system [<http://www-eosdis.ornl.gov/>] and the anonymous FTP site [<ftp://www-eosdis.ornl.gov/data/>] or by contacting User Services by electronic mail, telephone, fax, letter, or personal visit using the contact information in Section 15.1.

15.4 Data Center Status/Plans

The ORNL DAAC is the primary source for BOREAS field measurement, image, GIS, and hardcopy data products. The BOREAS CD-ROM and data referenced or listed in inventories on the CD-ROM are available from the ORNL DAAC.

16. Output Products and Availability

16.1 Tape Products

ESA has a policy that ERS-1 data may be distributed only to ESA-approved investigators; hence, the reference ERS-1 mosaic may not be utilized without first requesting an authorization from ESA. The ERS change maps, which correspond to a higher level product, can be utilized with no restriction.

The RSS-17 freeze/thaw image data can be made available on 8-mm, Digital Archive Tape (DAT).

16.2 Film Products

None.

16.3 Other Products

The BOREAS RSS-17 freeze/thaw image data are available on the BOREAS CD-ROM series.

17. References

17.1 Platform/Sensor/Instrument/Data Processing Documentation

Excerpts were taken from the following to document this data set:

http://www.asf.alaska.edu/source_documents/ers1_source.htm

http://www.asf.alaska.edu/sensor_documents/ami_sensor.html

Welch, T.A. 1984. A Technique for High Performance Data Compression. IEEE Computer, Vol. 17, No. 6, pp. 8-19.

17.2 Journal Articles and Study Reports

Newcomer, J., D. Landis, S. Conrad, S. Curd, K. Huemmrich, D. Knapp, A. Morrell, J. Nickeson, A. Papagno, D. Rinker, R. Strub, T. Twine, F. Hall, and P. Sellers, eds. 2000. Collected Data of The Boreal Ecosystem-Atmosphere Study. NASA. CD-ROM.

Rignot, E. and J. Way. 1994. Monitoring freeze/thaw cycles along north-south Alaskan transects using ERS-1 SAR. Rem. Sens. Environ. 49:131-137.

Rignot, E. et al. 1994. Monitoring of environmental conditions in taiga forests using ERS-1 SAR. Rem. Sens. Environ. 49:145-154.

Sellers, P. and F. Hall. 1994. Boreal Ecosystem-Atmosphere Study: Experiment Plan. Version 1994-3.0, NASA BOREAS Report (EXPLAN 94).

Sellers, P. and F. Hall. 1996. Boreal Ecosystem-Atmosphere Study: Experiment Plan. Version 1996-2.0, NASA BOREAS Report (EXPLAN 96).

Sellers, P., F. Hall, and K.F. Huemmrich. 1996. Boreal Ecosystem-Atmosphere Study: 1994 Operations. NASA BOREAS Report (OPS DOC 94).

Sellers, P., F. Hall, and K.F. Huemmrich. 1997. Boreal Ecosystem-Atmosphere Study: 1996 Operations. NASA BOREAS Report (OPS DOC 96).

Sellers, P., F. Hall, H. Margolis, B. Kelly, D. Baldocchi, G. den Hartog, J. Cihlar, M.G. Ryan, B. Goodison, P. Crill, K.J. Ranson, D. Lettenmaier, and D.E. Wickland. 1995. The boreal ecosystem-atmosphere study (BOREAS): an overview and early results from the 1994 field year. Bulletin of the American Meteorological Society. 76(9):1549-1577.

Sellers, P.J., F.G. Hall, R.D. Kelly, A. Black, D. Baldocchi, J. Berry, M. Ryan, K.J. Ranson, P.M. Crill, D.P. Lettenmaier, H. Margolis, J. Cihlar, J. Newcomer, D. Fitzjarrald, P.G. Jarvis, S.T. Gower, D. Halliwell, D. Williams, B. Goodison, D.E. Wickland, and F.E. Guertin. 1997. BOREAS in 1997: Experiment Overview, Scientific Results and Future Directions. Journal of Geophysical Research 102(D24): 28,731-28,770.

Way, J.B., R. Zimmermann, E. Rignot, K. McDonald, and R. Oren. 1997. Winter and spring thaw as observed with imaging radar at BOREAS. Journal of Geophysical Research 102(D24): 29,673-29,684.

17.3 Archive/DBMS Usage Documentation

None.

18. Glossary of Terms

None.

19. List of Acronyms

AMI	- Active Microwave Instrumentation
ASCII	- American Standard Code for Information Interchange
ASF	- Alaska SAR Facility
ATSR	- Along-Track Scanning Radiometer
BOREAS	- BOREal Ecosystem-Atmosphere Study
BORIS	- BOREAS Information System
CD-ROM	- Compact Disk-Read-Only Memory
DAAC	- Distributed Active Archive Center
DN	- Digital Number
DOY	- Day of Year
EOS	- Earth Observing System
EOSDIS	- Earth Observing System Data and Information System
ERS	- European Remote Sensing Satellite
ESA	- European Space Agency
GIS	- Geographic Information System
GSFC	- Goddard Space Flight Center
HTML	- HyperText Markup Language
JPL	- Jet Propulsion Laboratory
LR	- Laser Retroreflector
MDA	- McDonnell Detweiler Associates
MWS	- Microwave Sounder
NAD83	- North American Datum of 1983
NASA	- National Aeronautics and Space Administration
NSA	- Northern Study Area
OBS	- Old Black Spruce
ORNL	- Oak Ridge National Laboratory
PANP	- Prince Albert National Park
PRARE	- Precise Range and Range Rate Experiment
RA	- Radar Altimeter
RSS	- Remote Sensing Science
SAR	- Synthetic Aperture Radar
SSA	- Southern Study Area
URL	- Uniform Resource Locator
UTC	- Coordinated Universal Time
WNS	- Wind Scatterometer

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20.4 Citation

Users of this data set should acknowledge Eric Rignot and JoBea Way at NASA JPL for providing the ERS change maps and the ESA for providing the ERS data. Also, please include citations of relevant papers in Section 17.2.

If using data from the BOREAS CD-ROM series, also reference the data as:

Way, J.B., R. Zimmerman, K. McDonald, and E. Rignot, "Freeze/Thaw Transitions as Observed with ERS-1 Imaging Radar at BOREAS." In *Collected Data of The Boreal Ecosystem-Atmosphere Study*. Eds. J. Newcomer, D. Landis, S. Conrad, S. Curd, K. Huemmrich, D. Knapp, A. Morrell, J. Nickeson, A. Papagno, D. Rinker, R. Strub, T. Twine, F. Hall, and P. Sellers. CD-ROM. NASA, 2000.

Also, cite the BOREAS CD-ROM set as:

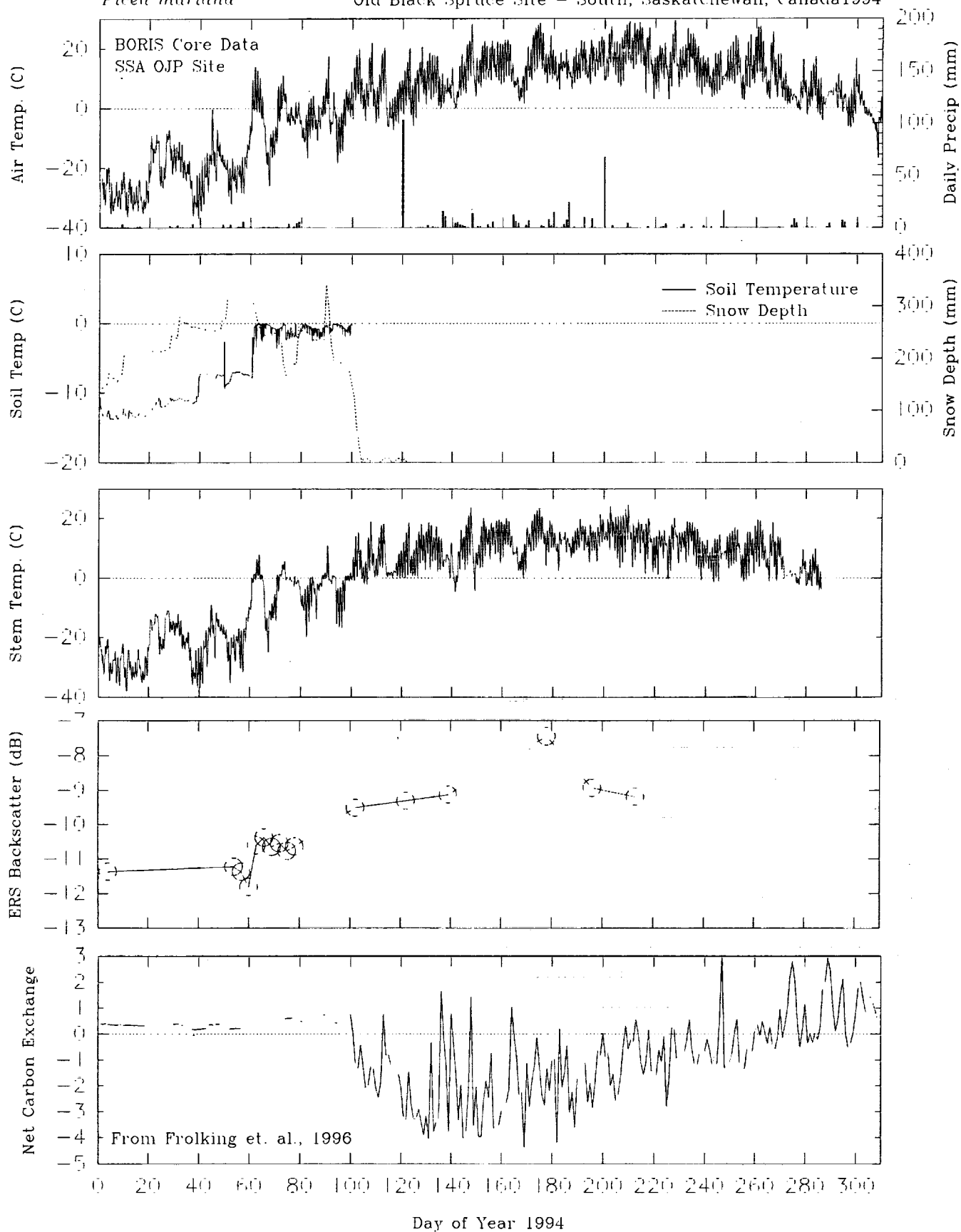
Newcomer, J., D. Landis, S. Conrad, S. Curd, K. Huemmrich, D. Knapp, A. Morrell, J. Nickeson, A. Papagno, D. Rinker, R. Strub, T. Twine, F. Hall, and P. Sellers, eds. *Collected Data of The Boreal Ecosystem-Atmosphere Study*. NASA. CD-ROM. NASA, 2000.

20.5 Document Curator

20.6 Document URL

Picea mariana

Old Black Spruce Site – South, Saskatchewan, Canada 1994



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13. ABSTRACT (Maximum 200 words) The BOREAS RSS-17 team acquired and analyzed imaging radar data from the ESA's ERS-1 over a complete annual cycle at the BOREAS sites in Canada in 1994 to detect shifts in radar backscatter related to varying environmental conditions. Two independent transitions corresponding to soil thaw and possible canopy thaw were revealed by the data. The results demonstrated that radar provides an ability to observe thaw transitions at the beginning of the growing season, which in turn helps constrain the length of the growing season. The data set presented here includes change maps derived from radar backscatter images that were mosaicked together to cover the southern BOREAS sites. The image values used for calculating the changes are given relative to the reference mosaic image. The data are stored in binary image format files.				
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